Design Thinking: Notes on Its Nature and Use

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Abstract

Problems induced by continuing population growth and its pressure on resources and environment have reached a stage where serious concern must be given to the processes of decision making being used by governmental and institutional leaders. Science thinking is frequently unheard or unheeded and design thinking is not engaged at all.

Design thinking, as a complement to science thinking, embodies a wide range of creative characteristics as well as a number of other special qualities of distinct value to decision makers. In advisory roles, properly prepared design professionals could make substantial contributions to a process now dominated by political and economic views. This paper examines the nature of design thinking as it differs from other ways of thinking. A model for comparing fields is introduced and a number of characteristics of creative individuals in general and designers in particular are presented.

Preparing designers for participation in policy planning will be a challenge for design education. Meeting the challenge will require new understanding, an extended range of design tools, and concerted support from the design professions to demonstrate the value of design thinking to decision making at the highest levels.

Introduction

The handiwork of humankind is finally beginning to impress itself on the global environment and on us, its inhabitants. This should inspire us as design professionals to reconsider what we do, who our clients are, and where we can best offer our expertise. In particular, the decision processes of high-level decision makers are in need of serious overhaul.

It is news to no one that current rates of resource consumption cannot keep up with population growth as it exists. World population is virtually certain by 2050 to increase by half again from its present 6.46 billion—with all that means for our dwindling resources. Coupled with that, it is at last clear that global warming is fact, and its growing control over Earth's climate and weather systems will unpredictably complicate problems already made serious by population pressures.

The road ahead indeed seems dark, but there is hope. A profusion of new technologies is emerging, many with potential to alleviate or even eliminate the problems induced by population growth. As Jared Diamond points

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He joined the IIT faculty in 1965 following studies for degrees in chemistry and product design, additional studies in city planning and computer science, and four years as an officer in the U.S. Navy. Since then, he has worked in the fields of product design, design planning, computer-supported design, design methodology and design theory—directing the Product Design program for 20 years, founding and directing the Design Processes Laboratory for 14 years, publishing the ***Design Processes Newsletter*** for 10 years, and teaching, conducting research and consulting. He has acted as advisor to several universities in the U.S. and abroad and has served or now serves on the advisory boards of the journals: ***Visible Language*** (U.S.), ***Design Recherche*** (France), ***Design Studies*** (UK), ***ARCOS*** (Brazil), ***Asia Design Journal*** (Korea), ***Journal of Design Excellence*** (Malaysia) and the Wiley International book series on design.

Professor Owen has written a number of computer programs for business and institutional applications, has published widely (over 125 articles, papers, books and book chapters), has served on international juries, and has been an invited lecturer at over 200 institutions in the U.S. and abroad. Among many awards his students have won are two Grand Prizes in the Japan Design Foundation's International Design Competition, the Grand Prize in Sony Corporation's International Design Vision Competition, and the 1991 Grand Award in the Environmental Technology category of ***Popular Science*** Magazine's 'The Year's 100 Greatest Achievements in Science and Technology'. In 1990, he was the recipient of the American Center for Design's Education Award for his contributions to design history, theory and practice. In 1995 he was honored at IIT with recognition as Distinguished Professor of Design. In 1997, he was elected Honorary Member of the Japanese Society for the Science of Design, the first in its 44 year history. In 1999 the Institute of Design honored his work with the establishment of an endowed Chair in his name, and he was named one of 36 'IIT People of the Millennium' by the university for his contributions.

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out[1], technologically complex societies autocatalyze technological growth, and the resulting development accelerates over time. We are, in effect, unintentionally creating the highly sophisticated tools that may prevent the destruction initiated with earlier created tools.

Key to the use or misuse of these technologies are the decision processes employed by those in power. History has shown that political decisions do not always favor the best interests of all, and when critical factors include information not easily understood by political decision makers, that information may be disregarded or not even considered. My argument in recent papers[2] is that the stakes are now too high for critical information to be unheard or ignored.

'Design thinking is in many ways the obverse of scientific thinking.'

Science advisors have long been included among high-level governmental advisory staffs. How their advice is valued, however, has varied with the problem context, and political interests have almost always trumped scientific advice. More than ever before, scientific advice requires serious consideration. And another kind of thinking deserves equal attention.

Design thinking is in many ways the obverse of scientific thinking. Where the scientist sifts facts to discover patterns and insights, the designer invents new patterns and concepts to address facts and possibilities. In a world with growing problems that desperately need understanding and insight, there is also great need for ideas that can blend that understanding and insight in creative new solutions. Implicit in this notion is the belief that design thinking can make special, valuable contributions to decision making. In this paper, I will explore the nature of that kind of thinking, its value, and the differences between design thinking and other ways of thinking.

Finders, Makers and Applied Creativity

A sensitive observer might notice an interesting thing about creative people. They tend to work in two different ways (Figure 1).

Those who work in the first way, might best be called 'finders'. They exercise their creativity through discovery. Finders are driven to understand, to find explanations for phenomena not well understood. In professional life, they usually become scientists or scholars and are responsible for much of our progress in understanding ourselves and our surroundings.

Those who work in the second way are 'makers', equally creative, but in a different way. They demonstrate their creativity through invention. Makers are driven to synthesize what they know in new constructions, arrangements, patterns, compositions and concepts that bring tangible, fresh expressions of what can be. They become architects, engineers, artists—designers —and are responsible for the built environment in which we live and work.

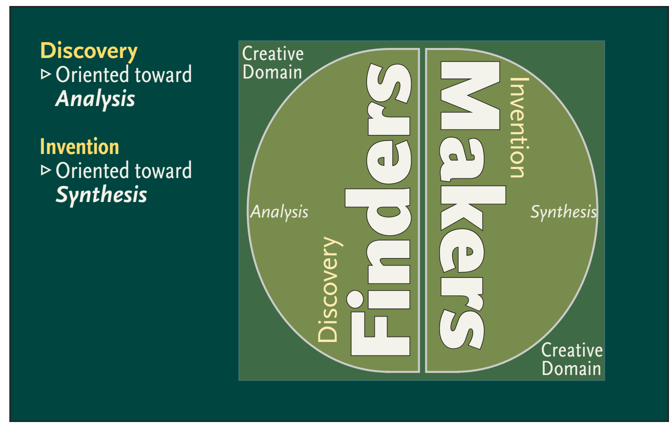

Figure 1 Two-domain Creativity Model

Design Thinking vs Other Kinds of Thinking

Given the fundamental process differences between how finders and makers think and work, it is reasonable to

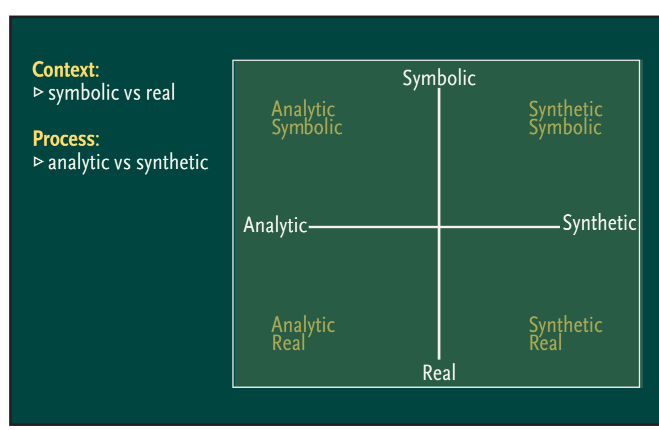

Figure 2 Map of Fields: Context and Process Differentiate

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believe that other factors might similarly reveal differences among professional fields and, therefore, help to define the nature of design thinking. One such factor is the content with which a field works. A conceptual 'map' can be drawn to use both content and process factors (Figure 2).

Two axes define the map. Separating the map into left and right halves is an Analytic/Synthetic axis that classifies fields by process—the way they work. Fields on the left side of the axis are more concerned with 'finding' or discovering; fields on the right with 'making' and inventing. A Symbolic/Real axis divides the map into halves vertically, according to content or realm of activity. Fields in the upper half of the map are more concerned with the abstract, symbolic world and the institutions, policies and language tools that enable people to manipulate information, communicate and live together. Fields in the lower half are concerned with the real world and the artifacts and systems necessary for managing the physical environment.

A sampling of fields illustrates how the map differentiates (Figure 3). The five chosen are highly recognizable with well defined disciplines and well understood differences. Every field has component elements in each of the four quadrants. What distinguishes one field from another is the degree to which a field positions its 'center of gravity' away from the center into the quadrants and the direction that positioning takes. In Figure 3, fields close to the center are more 'generalized' with respect to the axes; fields away from the center are more 'specialized'.

Science is farthest to the left as a field that is heavily analytic in its use of process. Its content is also more symbolic than real in that subject matter is usually abstracted in its analyses. There are elements of science, however, that are synthetic in process (as, for example, in materials science or organic chemistry), and science can deal directly with unabstracted, real content, particularly in the natural sciences.

Law, as a generalized field, is located higher on the map, concerned extensively with the symbolic content of institutions, policies and social relationships. It is also positioned more to the right, as a significant portion of its disciplines are concerned with the creation of laws and the instruments of social contract. Medicine, in contrast, is sharply lower on the content axis, vitally concerned with the real problems of human health. On the process scale, it is strongly analytic; diagnostic processes are a primary focus of medicine. Art is high on the content axis, strongly symbolic, and almost evenly divided on the process scale, still more synthetic than analytic, but very much involved with interpretation of the human condition.

Design in this mapping is highly synthetic and strongly concerned with real world subject matter. Because disciplines of design deal with communications and symbolism, design has a symbolic component, and because design requires analysis to perform synthesis, there is an analytic component—but design is a field relatively specialized, and specialized nearly oppositely to science.

For almost any field, a case can be made for movement to the left or right based on the variety of detailed interests the field subsumes. Positioning is very subjective, but absolute positioning is not what is important in this kind

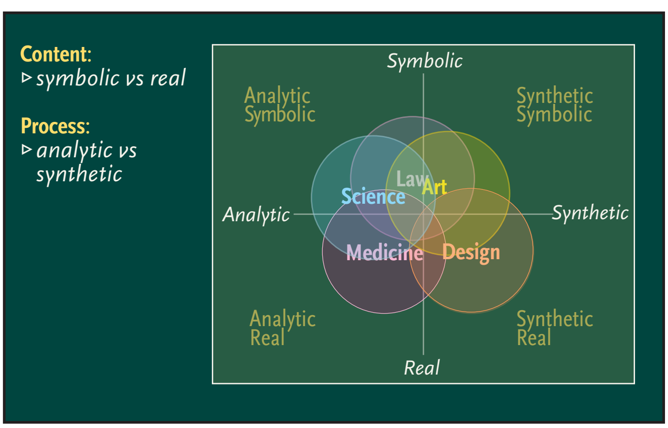

Figure 3 Differences: Discrimination among Fields

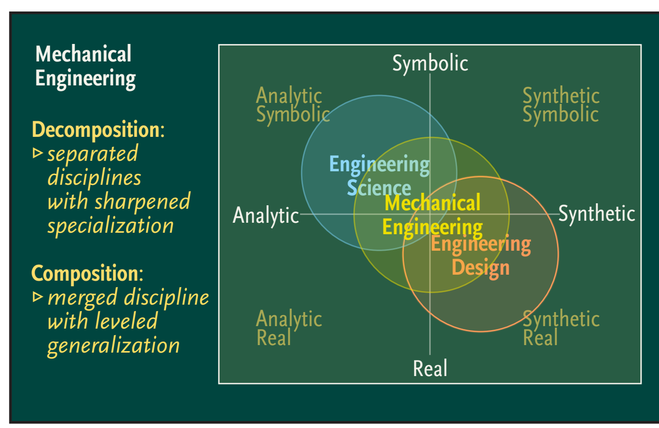

Figure 4 Hierarchy: Fields Decompose to

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of mapping. Relative positioning is. It provides a means for comparing multi-field relationships with regard to the two important dimensions of content and process.

Fields, of course, are just the tops of hierarchies, and the hierarchical nature of their subject matter opens a door to the examination of relationships among elements at finer levels of detail (Figure 4). Mechanical engineering, a subject at the discipline level, is nicely centered between the analytic and synthetic domains, but that is only true when it is considered as a whole. Engineering science, one of its sub-disciplines, would be located much farther to the left; engineering design would be on the right. Decomposing mathematics produces, among other subspecialties, applied mathematics, which is concerned more generally with the real domain than is mathematics, the parent discipline. The complexity of most fields affords opportunities for such leveling and sharpening through hierarchical examination. Composition is a leveling process, lessening distinctions and moving more inclusive concepts, such as fields, toward the center of the map; decomposition is a sharpening process, revealing differences and dispersing more tightly defined disciplines and sub-disciplines into the quadrants.

Movements of fields and disciplines through time and culture can also be tracked. Through much of the last two thousand years, for example, western sculptors rendered realistic subjects for their clients, commemorating individuals and events. Since the turn of the last century, cultural trends in the arts have moved sculpture up and to the left on the map. Architecture in this century has moved up and down on the map as various movements have shifted the discipline's focus of interest between symbolic and functional goals.

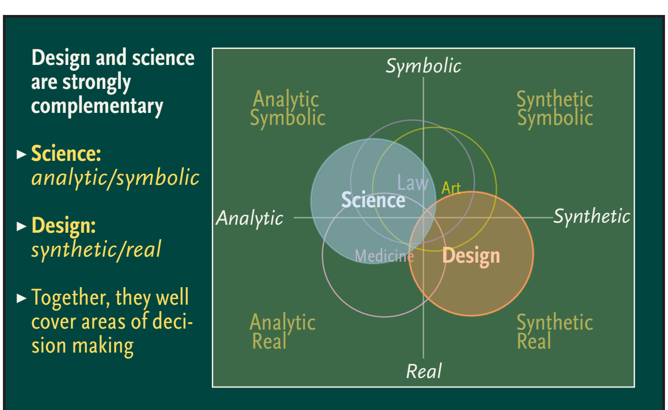

Figure 5 Differences: Design and Science are Complementary

A field's choice of subject matter and procedure distinguishes it from others. Design, as a field, clearly occupies a special place on the map, more complementary to science than any other field in that, coupled with science, it fills out the space most completely (Figure 5). The source of the complementation lies in deeply rooted differences in ways of thinking. To understand the differences, it is useful to look at how knowledge is built and used in a field.

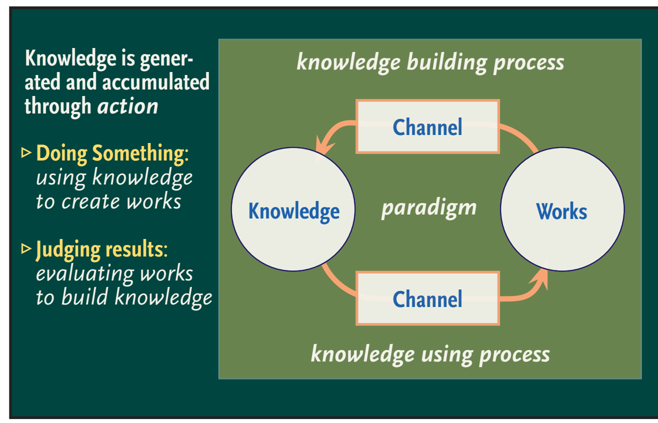

Figure 6 Foundations: Knowledge Building; Knowledge Using

Foundations

In any field, knowledge is generated and accumulated through action: the model is doing something and evaluating the results. In Figure 6, the process is shown as a cycle in which knowledge is used to produce works, and

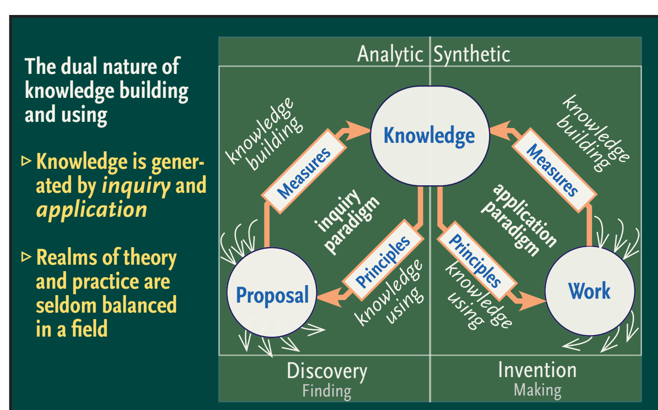

Figure 7 Foundations: Paradigms of Inquiry and Application

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works are evaluated to build knowledge. Knowledge using and knowledge building are both structured processes controlled by channels that contain and direct the production and evaluation processes.

These channels are the systems of conventions and rules under which a field and its disciplines operate. They embody the values and integrate the principles and measures that have evolved as 'ways of doing and knowing' as the field has matured. They may borrow from or emulate aspects of other fields' channels, but over time, they become custom tailored to a field as products of its evolution.

The general model can be extended to one that reflects the dual nature of fields and disciplines suggested by the analytic/synthetic dimension of the Map of Fields. In Figure 7, this is done with an addition of realms of theory and practice within which paradigms of inquiry and application operate[3].

Underlying knowledge building and knowledge using in any field are deep foundation layers that direct and inform higher levels all the way to the level of overt procedure. In order from most fundamental to most directly operational, these can be expressed as needs or goals, values and measures. Qualities that a field exhibits on the surface and differences among fields can be best understood by examining these foundations.

Figure 8 presents the foundation model diagrammatically. At the most fundamental level, a driving force—a need/goal that must be satisfied—generates a field. For any well-defined field this usually can be encapsulated in a word, the purpose for which the field evolved. For disciplines, as the focused specialties of a field, it is frequently a need felt strongly and seen purely enough to enlist individuals in a career.

From a need or goal, values emerge to identify the qualities important to fulfilling the need. The work of the field is evaluated in terms of these values. Both needs and values exist at an abstract level, providing reference and foundation against which procedures at an operational level can be tested.

The third and fourth layers of the model take values into the domain of action. The third layer, still relatively abstract, is concerned with the interpretation of values into measures that guide the creation of instruments to manage the processes of knowledge using and building. Measures are conveniently conceptualized as scales. Because they include expressions for the description of quality at high and low ends, and can have intermediate descriptions as well, they form an ideal bridge from single-word notions of value to evaluative dimensions. Most typically, measurement scales are bipolar with a 'good' side and a 'bad' side (e.g., true/false, right/wrong, works/doesn't work, etc.), but

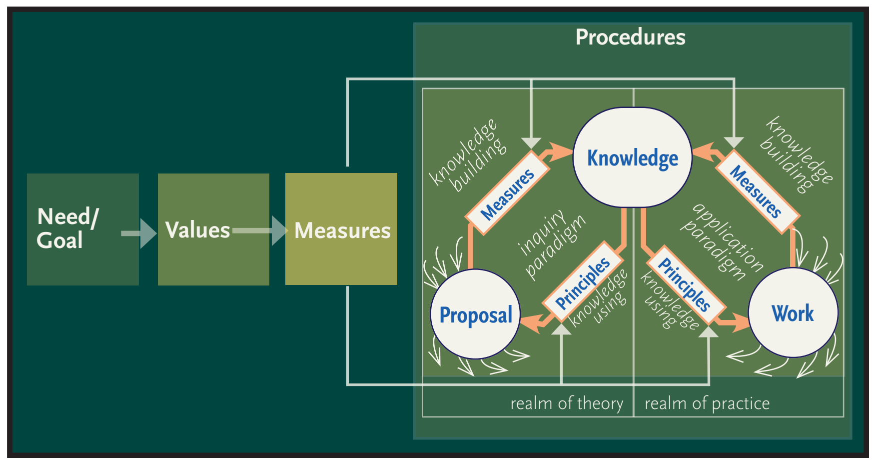

Figure 8 Foundations: Fields Are Founded upon Values

they need not be. Triangular and higher dimension scales (essentially maps) also work, but are less readily applied. Further, scales need not be continuous or even multi-stepped. True/false is perfectly valid as a binary yes/no proposition. And they need not be linear; whether steps are uniform or progressively larger or smaller is not at issue—the issue is resolution in the measurement of value.

The value frameworks created by measures guide the formation of operational methods for producing and judging work. Methods, in turn, combine into the familiar working procedures and processes that encode the knowledge of the discipline operationally for paradigms of both application and inquiry.

Figure 9 uses the model to compare design with the four previously introduced fields. The measures suggested are examples, by no means a complete set.

Science is driven by the need for Understanding. To achieve this goal, it values Correctness, in the sense that theories can be evaluated for whether they are correct, as best can be determined with current data. It also values Thoroughness because understanding must be thorough to remove uncertainty. Testability is valued because closure

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demands that theories be tested and determined to be correct or incorrect. These values (and others) find expression in measures that expand the essence of the value into tools that can be incorporated directly or indirectly in frameworks, methods and procedures. Measures such as True/False, Correct/Incorrect, Complete/Incomplete, and Provable/Unprovable exemplify these.

Art, quite different in this kind of analysis, derives from the need for Expression. Values such as Insightfulness, Novelty and Stimulation highlight important aspects of expression as it is regarded today, and measures such as Thought provoking/Banal, Fresh/Stale and Exciting/Boring particularize these for the criteria to be used in the production and criticism of art.

Law strives for Justice. Its values, Fairness, Thoroughness and Appropriateness, are concerns important to writing the law and ensuring that it is properly used in support of good citizenship. Measures such as Just/Unjust, Right/Wrong, Complete/Incomplete, Appropriate/Inappropriate and Fair/Unfair draw out the evaluations appropriate to the field.

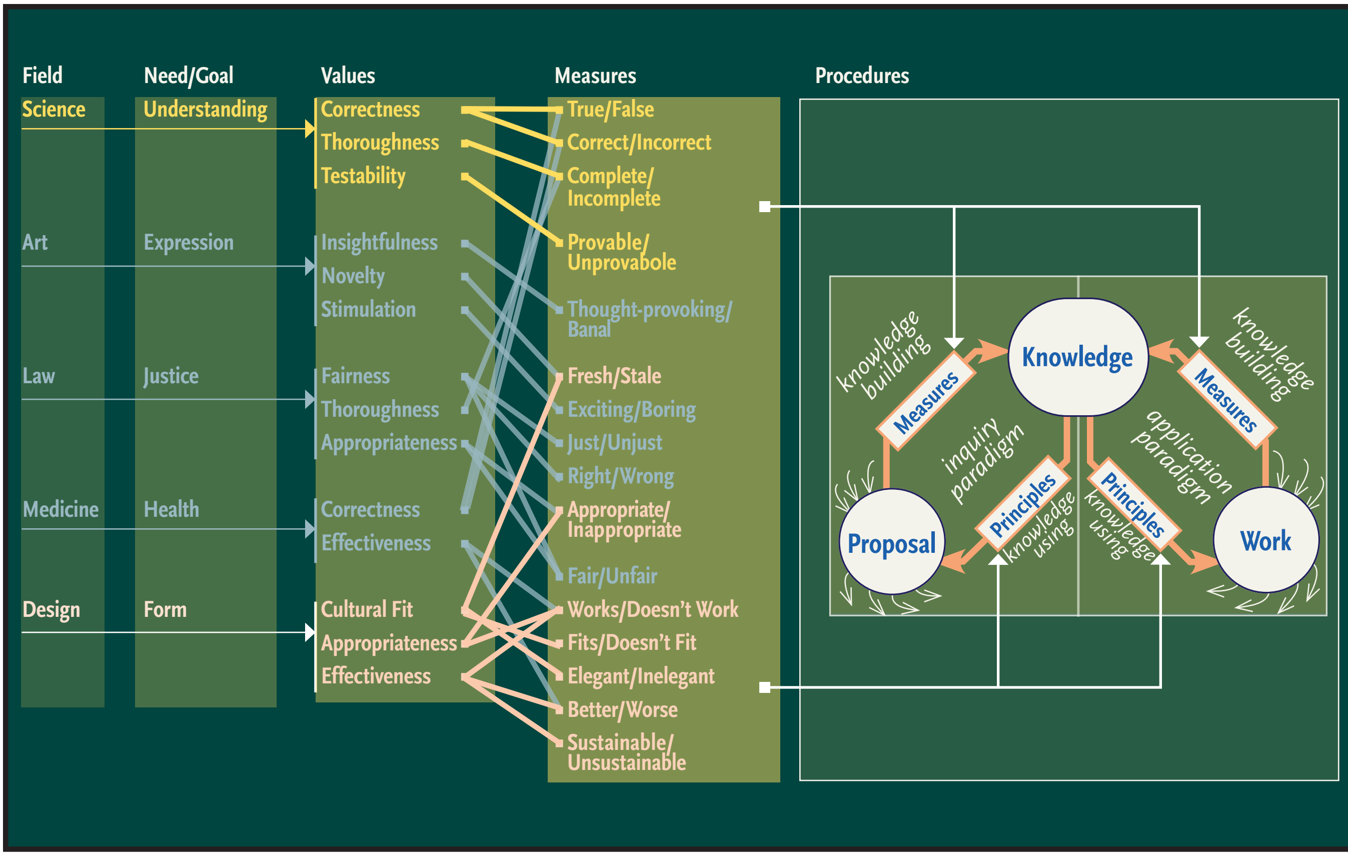

Figure 9 Foundations: Viewpoints and Values for Science, Art, Law, Medicine, and Design

Medicine shares much with science, but has its own need for being in maintaining, promoting and regenerating Health. Among its values, Correctness is critical for diagnoses and procedures, and Effectiveness, a value strongly shared with design, is relevant when something is better than nothing. Measures include Correct/Incorrect, Works/Doesn't work and Better/Worse.

Design exists because of the need for Form. The form giver, in the broadest use of the term, creates order. Because the world of design is the world of the artificial, the values of design tend to be ones associated with human needs and environmental needs created by or resulting from human actions. Cultural Fit is associated with aesthetic issues; Appropriateness targets the wide range of

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physiological, cognitive, social and cultural human factors; and Effectiveness gauges functionality and utility. For Cultural Fit, good measures are Fresh/Stale, Fits/Doesn't Fit and Elegant/Inelegant; for Appropriateness, Appropriate/Inappropriate and Works/Doesn't Work (from the human factors perspective) are helpful. From a utility perspective, Works/Doesn't Work, Sustainable/Unsustainable and Better/Worse measure Effectiveness.

'...a combination of science thinking and design thinking is better than either alone as a source of advice.'

Seen through the differences in underlying values, differences among fields become clearer and more understandable. As a case in point, a major difference between science and design lies in the difference between Correctness and Effectiveness as important measures of success. Correct/Incorrect (or True/False) is appropriate for a field in which there can only be one 'true' answer or correct explanation for an observed phenomenon. Better/Worse is appropriate for a field in which multiple solutions can be equally successful because the conditions for judgment are culturally based.

From all this, it is easier to see why a combination of science thinking and design thinking is better than either alone as a source of advice. Either is valuable, but together they bring the best of skeptical inquiry into balance with imaginative application. Both are well served by creative thinking. In preparation for a wider consideration of design thinking, therefore, it is time to look at the general characteristics of the creative thinker.

Characteristics of Creative Thinking

Despite great interest and considerable speculation over many years, the nature of creativity, what makes one person creative and another not, and the creative process itself, remain elusive. Nevertheless, a number of characteristics have been identified and these can be useful in contemplating the nature of creative thinking and, in particular, creative design thinking as it is and as we would like it to be.

Fabun's List

In a special issue of *Kaiser Aluminum News* some years ago, editor Don Fabun assembled characteristics of the creative individual culled from the observations of a number of thoughtful writers[4]. While they are not all-inclusive, they provide a good start for assembling a catalog:

- *Sensitivity.* A propensity for greater awareness which makes a person more readily attuned to the subtleties of various sensations and impressions. Eric Fromm[4] writes, 'Creativity is the ability to see (or be aware) and to respond'.
- *Questioning attitude.* An inquisitiveness, probably imprinted in early home training that encourages seeking new and original answers.
- *Broad education.* An approach to learning instilled from a liberal education that puts a premium on questions rather than answers and rewards curiosity rather than rote learning and conformity.
- *Asymmetrical thinking.* The ability to find an original kind of order in disorder as opposed to symmetrical thinking that balances everything out in some logical way. 'The creative personality is unique in that during the initial stages he prefers the chaotic and disorderly and tends to reject what has already been systematized'. Ralph J. Hallman[4]
- *Personal courage.* A disregard for failure derived from a concern, not for what others think, but what one thinks of oneself. 'They seemed to be less afraid of what other people would say or demand or laugh at ... Perhaps more important, however, was their lack of fear of their own insides, of their own impulses, emotions, thoughts'. Abraham Maslow[4]
- *Sustained curiosity.* A capacity for childlike wonder carried into adult life that generates a style of endless questioning, even of the most personally cherished ideas. Eric Fromm[4]: 'Children still have the capacity to be puzzled... But once they are through the process of education, most people lose the capacity of wondering, of being surprised. They feel that they ought to know everything, and hence that it is a sign of ignorance to be surprised or puzzled by anything'.
- *Time control.* Instead of being bound by time, deadlines and schedules, creative individuals use time as a resource—morning, noon and night—years, decades—whatever it takes, unbound by the clock.
- *Dedication.* The unswerving desire to do something, whatever it may be and whatever the obstacles to doing it.

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- ***Willingness to work.*** The willingness to continue to pursue a project endlessly, in working hours and so-called free hours, over whatever time might be required. Roger Sessions[4] said, 'Inspiration, then, is the impulse which sets creation in movement; it is also the energy which keeps it going'.

Additions from Arieti

In 1976, psychiatrist Silvano Arieti thoroughly reviewed what was known then about creativity[5]. From his study, several additional characteristics can be included:

- ***Fluency of thinking.*** Word fluency, the ability to produce words containing specified letters or combinations of letters; associational fluency, the ability to produce synonyms for given words; expressional fluency, the ability to juxtapose words to meet the requirements of sentence structure, and ideational fluency, the ability to produce ideas to fulfill certain requirements— to offer solutions to problems.
- ***Flexibility.*** The ability to abandon old ways of thinking and initiate different directions.
- ***Originality.*** The ability to produce uncommon responses and unconventional associations.
- ***Redefinition.*** The ability to reorganize what we know or see in new ways.
- ***Elaboration.*** The capacity to use two or more abilities for the construction of a more complex object.
- ***Tolerance for ambiguity.*** The capacity to entertain conflicting concepts for periods of time without the need to resolve uncertainties.

Csikszentmihalyi's Polarities

Mihaly Csikszentmihalyi, an anthropologist at the University of Chicago, sees the creative individual in terms of 'pairs of apparently antithetical traits that are often both present in such individuals and integrated with each other in a dialectical tension'[6].

- ***Generalized libidinal energy and restraint.*** 'Without eros, it would be difficult to take life on with vigor; without restraint, the energy could easily dissipate.'
- ***Convergent and divergent thinking.*** Divergent thinking to generate ideas; convergent thinking to tell a good one from a bad one.
- ***Playfulness and discipline—or irresponsibility and responsibility.*** Exploring ideas widely and lightly, but surmounting obstacles and bringing ideas to completion with doggedness, endurance and perseverance.
- ***Fantasy and reality.*** Breaking away from the present without losing touch with the past; finding originality in which novelty is rooted in reality.
- ***Extroversion and introversion.*** Seeing and hearing people, exchanging ideas, and getting to know other persons' work to extend interaction; working alone to fully explore and master abstract concepts.
- ***Humility and pride.*** Humility in the awareness of those who worked before, the element of luck involved with achievement, and the relative unimportance of past achievements in comparison with a focus on future projects; pride in the self-assurance associated with accomplishment.
- ***Masculinity and femininity.*** Psychological androgyny enabling the best traits of bold, assertive masculinity to be combined with the best traits of sensitive, aware femininity.
- ***Traditional conservatism and rebellious iconoclasm.*** Being able to understand and appreciate a cultural domain and its rules, while at the same time being willing to take risks to break with its traditions.
- ***Passion and objectivity.*** Passion in the attachment and dedication to the cause or work; objectivity in the ability to stand apart, detached, to evaluate quality impartially.
- ***Suffering and enjoyment.*** The heightened highs and lows that come with intense involvement and sensitivity, both to observed quality and to what others think.

Csikszentmihalyi notes that these conflicting traits are difficult to find in the same person, but 'the novelty that survives to change a domain is usually the work of someone who can operate at both ends of these polarities—and that is the kind of person we call creative'.

Many of these characteristics, especially among those listed by Csikszentmihalyi, are not qualities to be taught. At best these are natural personality traits that can be recognized where they exist or noted in their absence, but many of the others can be developed or encouraged, and this should be done overtly.

Characteristics of Design Thinking

Creativity is of major importance to design thinking, as it is to science thinking and thinking in any field. But as is true for each field, characteristics other than creativity are

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also important. From personal experience, I would nominate for design thinking the following characteristics and ways of working:

- ***Conditioned inventiveness.*** Creative thinking for designers is directed toward inventing. Designers tend to be more interested in the 'what' questions than the 'whys' of interest to the scientist. Design creativity, thus, complements scientific creativity. Design creativity, however, must cover more than just invention. Design brings to invention a concern that what is produced not only be inventive, but be so within the frameworks of human-centered and environment-centered measures governing the designer's efforts.
- ***Human-centered focus.*** Science and, to a slightly lesser extent, technology have few built-in governors. That is to say, as in the arts, exploration proceeds where discoveries direct. Design, on the other hand, is client-directed. Design thinking must continually consider how what is being created will respond to the clients' needs.
- ***Environment-centered concern.*** In recent years, design thinking has acquired a second, omnipresent and meta-level client: the environment. Present-day thinking puts environmental interests at a level with human interests as primary constraints on the design process. Sustainable design is one very noticeable result, The ultimate value of human- and environment-centeredness is a guarantee that the best interests of humankind and environment will be considered in any project.
- ***Ability to visualize.*** All designers work visually. Designers can visualize ideas in a range of media, bringing a common view to concepts otherwise imagined uniquely by everyone in a discussion. Designers can reveal the whole elephant that the blind men can only partially and imperfectly conceive.
- ***Tempered optimism.*** It is difficult to work—and especially to work creatively—in a pessimistic, critical mood. Designers are taught to recognize this and to establish optimistic and proactive ways of working. Pronounced mood swings are not unusual among creative individuals, but designers learn to control these to level out both lows and highs in the interests of professionalism—designers must be able to turn on enthusiasm on demand.
- ***Bias for adaptivity.*** In recent years, the emergence of adaptive processes in manufacturing and information technologies has greatly reinforced a practice historically followed by some designers: the design of adaptive products able to fit their users' needs uniquely. Design thinking today has accepted that concept, approaching problems with the view that, where possible, solutions should be adaptive—in production, to fit the needs of users uniquely; throughout their use, to fit users' evolving needs.
- ***Predisposition toward multifunctionality.*** Solutions to problems need not be monofunctional. Designers routinely look for multiple dividends from solutions to problems. This would seem to be an obvious way to proceed, but it is not so. In a recent issue of *Popular Science* magazine[7], the cover story was six new technologies to stop global warming. The story reported proposals made by the science community at a special invited meeting with White House officials. All six science proposals were serious proposals for macroengineering projects. Five of the six proposed single-minded means for relieving global warming—at considerable cost, and with no additional benefits. The sixth, as an extension of a technology already used for increasing natural gas production, had that benefit, but no other. In contrast, the three macro design projects proposed in the Institute of Design's prize winning Project Phoenix (also reported in Popular Science 14 years earlier) all had major economic benefits in addition to their global warming benefits[8]. Design thinking keeps the big picture in mind while focusing on specifics.
- ***Systemic Vision.*** Design thinking is holistic. In the last forty years, roughly since the computer began to influence design thinking, designers have moved to considering problems more broadly. Modern design treats problems as system problems with opportunities for systemic solutions involving mixes of hardware, software, procedures, policies, organizational concepts and whatever else is necessary to create a holistic solution.
- ***View of the Generalist.*** Common wisdom today holds that the trend of expertise is to greater and greater specialization and, therefore, success will come more readily to those who choose to specialize early and plan their training accordingly. Design thinking, to the contrary, is highly generalist in preparation and execution. In a world of specialists, there is real need for those who can reach across disciplines to communicate and who can bring diverse experts together in coordinated effort. For inventive creativity, the wider the reach of the knowledge

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base, the more likely the creative inspiration. A designer is a specialist in the process of design, but a generalist in as wide a range of content as possible.

- ***Ability to use language as a tool.*** Language is usually thought of as means for communication. For design thinking, it is also a tool. Visual language is used diagrammatically to abstract concepts, reveal and explain patterns, and simplify complex phenomena to their fundamental essences. Mathematical language is used to explore 'what if' questions where feasibility may be established by approximation—by calculations not exact, but close enough to support an idea or change a line of reasoning. Verbal language is used in description where explanation goes hand in hand with the creative process, forcing invention where detail is lacking and expressing relationships not obvious visually.
- ***Affinity for teamwork.*** Because designers work for clients, it is natural that good interpersonal skills become part of the professional set of tools they develop. An additional impetus toward teamwork has been a movement in the professions over the last forty years toward team-based design, spurred by developments in industry. Design thinking today is highly influenced by this, and designers routinely work closely with other designers and experts from other fields. On multi-discipline teams, designers are a highly valuable asset because of their characteristic abilities to generalize, communicate across disciplines, work systematically with qualitative information, and visualize concepts.
- ***Facility for avoiding the necessity of choice.*** The job of the decision maker is to choose among alternative proposals, usually the products of different problem-solving approaches. Design thinking takes the view that making that choice is a last resort. Before moving to choice-making, the designer looks for ways to 'have your cake and eat it too'—a seeming paradox (exactly what you cannot do, as pointed out in the old English proverb). The optimistic, adaptive designer, however, searches the competing alternatives for their essential characteristics and finds ways to reformulate them in a new configuration. When this process is successful, the result is a solution that avoids the decision and combines the best of both possible choices.
- ***Self-governing practicality.*** Design is a field in which inventiveness is prized. In very few fields is there the freedom to dream expected in design. The best design thinkers understand this and learn to govern flights of fantasy with a latent sense of the practical. The flight is to the outer reaches of what can be conceived; the tether is to ways that the conceivable might be realized. This is embedded in a style of thinking that explores freely in the foreground, while maintaining in the background a realistic appraisal of costs that can be met and functionality that can be effected.
- ***Ability to work systematically with qualitative information.*** As design research has matured and design methodology progressed, design processes with component methods and tools have been developed and refined. As one such process, Structured Planning[9] contains a tool-kit of methods for a complete range of planning tasks covering ways to find information, gain insights from it, organize it optimally for conceptualization, evaluate results and communicate a plan to the public and follow-on teams in the development process. Methods such as this are qualitative information handling techniques applicable to many kinds of conceptual problems where complex, system solutions are desirable. They are also usable by anyone working on a planning team, enabling systematic aspects of design thinking to be made accessible to all.

Design Education to Serve New Clients

The characteristics enumerated above are not those normally listed in a catalog for a design course. These are special ways of design thinking, almost implicit in the nature of the design process and usually taught tacitly in today's design education programs. For most of the characteristics, this works because design education programs are several years in length and directed toward a career in design. There is ample opportunity to acquire the skills and nuances of design thinking, and a predisposition to do so exists on the part of students because they have chosen to become designers. For some of the characteristics, though, particularly those that have developed more recently, tacit assimilation is not enough, and more progressive schools can be expected to institute formal courses to teach them.

We can expect problems to appear, moreover, when the context is changed. Teaching design thinking, formally or tacitly, is one thing when the context is a traditional design career in industry or a consulting office. It will be quite another when the context is institutional or governmental policy planning. And our problem is just that: to train a new kind of student for that new context. To train students

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for roles as policy design synthesis advisors, it will be necessary to create a new kind of design program. Some of the factors that will need to be considered are:

- **How long should the program be?** Can it be taught in one, two or three years? Should it be full-time or part-time—or either? It is unlikely that a long program will be acceptable. Just as business schools have crafted one and two year programs for executives seeking MBA degrees, a program for policy design synthesis will in all likelihood have to be relatively condensed and, perhaps, packaged in unusual time blocks and delivery means accessible to potential students already working in design or planning fields.
- **Who are the best candidates for the program?** Should candidates be recruited from institutional/governmental positions? Should experienced senior designers be recruited? It is not clear yet whether planners turned design thinkers or designers turned planning practitioners would be better. The correlated question whether senior designers or policy staff members would benefit more than young professionals in either field is also open. Perhaps, analogous programs for policy planning will be instructive.
- **What levels of experience and schooling should be required for entrance to the program?** Must candidates have one or more design degrees? What kind of experience is valuable? Should special experience be required? Some level of experience will almost certainly be necessary and training in both design and planning must be undertaken, either prior to entry or during the period of education. Experience can be built up through internships within the program, and varying degrees of foundation education can be offered as additional required studies for deficient candidates who otherwise would be highly qualified.
- **What is the ideal mix of design tools and thinking and tools and thinking from other fields to best prepare students for their working environment?** What tools from the available design inventory are suitable? What modifications should be sought? What tools from other fields could be refined for this new use? What wholly new tools would be desirable? Design research will have some new fields to probe. Tools will have to cover at least three sectors of policy design synthesis. First, tools for design advisors to work with other planning advisors. These will probably be information handling tools, much like Structured Planning, where all can work together under guidance by someone trained in using the tools. Second, tools for design advisors to work for other planning advisors. These will be tools that require more design expertise, but whose use is for crystallizing concepts for the planning group. Third, tools for design advisors to work away from other planning advisors. These will probably be tools for specialized design simulation and modeling work whose results will be important for the planning process, but whose workings require more specialized knowledge and time use than is reasonable for team members working directly on the planning problem.
- **What mix of academic and internship experience should be planned?** What form should the educational process take? Should elements of the program be on-site at an institutional location? Packaging of the program will be crucial to its success. If it achieves a high level of attention at executive levels, many otherwise highly effective, but costly, forms of education may become possible. Very low student-to-teacher ratios complemented with learning settings optimally suited to the education process are an example. The mix of experiences and forms of involvement should be planned for maximum effect in minimum time to appeal to a potential student population (and clients desiring to hire them) in position to expect—and sponsor—the best. How should successful completion of the program be judged? Course completion? Thesis or dissertation? License? Should examiners include internship advisors from relevant institution?

The opportunity may be here for new forms of evaluation. Design thinking is almost never evaluated well by testing, and almost all design is taught by 'project-oriented' learning methods. Final research work as typified by theses and dissertations is probably also inappropriate for the kind of program that most likely will evolve for policy design synthesis. A project-like demonstration of proficiency that could take a range of possible forms might be an answer. Such a demonstration could involve other students and have evaluators from both the university and the institution where the student is serving his or her internship.

The task of creating a Policy Design Synthesis program will be difficult. Governmental and institutional organizations must be convinced that policy design synthesis is a valuable addition to the advisory skills they rely upon. For that, our professional design societies can carry the cam-

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paign. New tools will have to be created to bring the skills of design thinking to bear on policy problems. For that, our design research institutions and university programs can lead the way. The problem is greater than the capabilities of any single university. Cooperation will be essential—to convince leaders, to create tools, and to train students in numbers significant to have impact—while there is still time.

Summary and Conclusions

The problems induced by a growing population are becoming major with virtual certainty that their number and seriousness will increase. Global warming, as one of the latest manifestations, adds levels of complication and uncertainty almost impossible to anticipate. Decision making at the policy level must avail itself of the best advice it can find to at once confront disasters on increasingly grander scales, and benefit from the emergence of extremely powerful new technologies.

To interpret the problems and possibilities of impending changes, science thinking must be solicited and heard. To explore and conceptualize ways to proceed, design thinking must receive equal attention. Among the many kinds of advice available, the creative voices of discovery and invention as embodied in the insights of scientists and the ideas of designers are critical.

Design thinking, less well known than science thinking, has characteristics of great value to teams dealing with complex, ill-formed problems. Together, the characteristics of design and science thinking form a set of complementary thought processes able to add considerable strength to the advisory task.

Providing design thinking in an advisory capacity to governmental and institutional leaders will require an evolution in design education, design research and design professional activities. For design education, new programs must be designed that bring the best of design thinking into the new context of policy planning. New content will be necessary; new processes must be developed and taught; and new ways of working will have to be learned. It will be worth doing.

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